Influence of Varying Drying Air Temperatures on Physico-chemical and Nutritional Characteristics of Bael (*Aegle marmelos*) Pulp

ABSTRACT

Drying is a critical process for preserving fruits, but the nutrients in fruits are highly sensitive to temperature. Finding an optimal drying temperature is crucial to maximizing the retention of nutritional and physico-chemical properties. This study investigated the effects of different drying air temperatures on properties of Bael fruit *(Aegle marmelos)* pulp. Fresh pulp was dried at 55°C, 65°C, and 75°C, and the resulting pulp was analyzed for physical, chemical, and nutritional changes compared to the fresh pulp. The results showed that drying at 65°C retained the most nutrition while preserving color and other physical properties. Color analysis indicated darkening and increased redness at higher temperatures. Chemical properties such as pH and ash content increased with drying, while titratable acidity was highest at 65°C. Nutritionally, protein content peaked at 65°C, while fat content increased steadily with drying air temperature. Fiber and ascorbic acid levels decreased as drying air temperatures rose.

Key words: Pulp, Physico- Chemical properties, Temperature difference

1. INTRODUCTION

Bael (*Aegle marmelos*), also known as Bengal quince or wood apple. Bael is a subtropical fruit tree species primarily native to the Indian subcontinent. India is the largest producer of Bael, followed by Bangladesh, Pakistan, and Sri Lanka. Within India, Bael cultivation is predominantly concentrated in the states of Odisha, Jharkhand, and Madhya Pradesh (Bhattacherjee et al., 2019).

Bael (*Aegle marmelos*), possesses substantial nutritional and therapeutic value. It serves as a significant source of diverse minerals, including phosphorus, potassium, calcium, magnesium, iron, copper, zinc, and chromium. The fruit's composition encompasses a complex matrix of macronutrients and micronutrients, featuring lipids, dietary fiber (comprising hemicellulose, cellulose, lignin, and pectin), proteins, and carbohydrates (Baliga et al., 2011). Bael is also replete with vitamins, notably thiamine (B1), riboflavin (B2), niacin (B3), and ascorbic acid (C). Furthermore, it contains a spectrum of essential amino acids, including threonine, valine, methionine, isoleucine, leucine, and lysine, as well as various fatty acids (Rahman et al., 2024). This nutritional profile underscores the fruit's potential as a functional food and its prospective applications in nutraceuticals and traditional medicine. The synergistic effects of these bioactive compounds merit further investigation to elucidate their mechanisms of action and potential health benefits (Sarkar et al., 2020).

Despite its considerable medicinal and therapeutic value, *Aegle marmelos* (Bael) fruit exhibits limited seasonal availability. As public health consciousness increases, the demand for nutrient-dense fruits like Bael is concomitantly rising (Anadani et al., 2023). Drying techniques offer a viable solution to extend the fruit's availability throughout the year. The process of drying inhibits microbial proliferation

by reducing water activity, thereby significantly extending the fruit's shelf life and preserving its bioactive compound (Quek et al., 2007).

There are several studies on the drying techniques on Bael. Among various dehydration methodologies, hot air tray drying emerges as a widely accessible and cost-effective technique for Bael fruit preservation (Tinebra et al., 2022). Fruits, being predominantly thermolabile, are susceptible to degradation of their nutritional components when exposed to elevated temperatures. Thermal processing may induce significant alterations in both the physico-chemical and organoleptic properties of fruits, including changes in color, water activity, and bulk density. These modifications can potentially impact the fruit's storage stability and market value (Kaur et al., 2016).

By systematically examining the thermal sensitivity of Bael pulp, this investigation seeks to optimize processing conditions that minimize nutritional degradation while ensuring microbial safety and extended shelf life. The findings of this study will contribute to the development of more accurate drying temperature for preserving Bael pulp, potentially enhancing its availability and marketability as a functional food ingredient.

2. MATERIAL AND METHODS

2.1 SAMPLE PREPARATION

Mature un-diseased Bael fruits (*Aegle marmelos)* were sourced from local producers. Selected fruits underwent aqueous cleaning to remove surface contaminants. The hard exocarp was fractured using a hammer, enabling extraction of the mesocarp, seeds, and fiber matrix. The extracted material was homogenized with water in a 1:1 ratio to facilitate separation. The resulting slurry was filtered through a sieve to isolate the pulp fraction from seeds and fibrous components (Saha & Jindal, 2018). The isolated fresh pulp (S1) was subjected to three different drying air temperature (55^0,65^0, and 75^0C) in hot air tray dryer to produce three distinct dried pulp samples namely S2, S3 and S4 at 55^0, 65^0, and 75^0C respectively.

Fresh Bael

Pulp extraction

Tray Drying of Pulp

2.2 DETERMINATION OF PHYSICAL PROPERTIES OF BAEL PULP SAMPLES

The bulk density of the samples was measured by putting sample into a beaker of known volume and weighing the sample which occupied the entire volume. The bulk density was then calculated as the ratio of the mass of the sample to the known volume of the beaker.

The true density was determined by using the toluene displacement method. A 5 g sample was submerged in toluene within a measuring cylinder with an accuracy of 0.1 ml. The displaced liquid volume, corresponding to the sample's true volume, was recorded and used to calculate the true density of the sample.

The color of the Bael sample was assessed using the CIE Lab colorimetric system. Standardized digital imagery was obtained using a high-resolution mobile camera under controlled illumination. Adobe Photoshop software was employed to analyze the captured images, with L*, a*, and b* values extracted from three separate areas per image. These parameters quantify lightness (L*), red-green balance (a*), and blue-yellow balance (b*). Results were reported as averages with standard deviations based on the triplicate color extractions.

2.3 DETERMINATION OF CHEMICAL PROPERTIES OF BAEL PULP SAMPLES

The chemical properties of Bael pulp samples were assessed through various analytical techniques. Total Soluble Solids (TSS) were measured using a handheld digital refractometer (HANNA HI 96801), which quantifies the refractive index to determine dissolved solids in °Brix. A 2 g sample was mixed with 50 mL of distilled water at room temperature, then thoroughly agitated with a vortex mixer at maximum setting (Hossain et al., 2021).

Titratable acidity was determined using the AOAC official method (AOAC International, 2016) by titrating a known sample volume against standardized NaOH solution to a pH endpoint of 8.1-8.2, with results expressed as the predominant organic acid and citric acid.

Ascorbic acid content was quantified through redox titration with 2,6-dichlorophenolindophenol (DCPIP), where ascorbic acid reduces DCPIP to a colourless form in an acidic environment, with the endpoint marked by a stable pink colour, reflecting the ascorbic acid concentration.

Water activity (a_w) was measured at 25°C using a Rotronic Hygroplam water activity meter, where the vapour pressure of the sample was compared to that of pure water.

The Water Solubility Index (WSI) was calculated by dispersing 2.0 g of sample in 24 mL of deionized water at 30°C, agitating at 150 rpm for 25 minutes, then centrifuging at 3500 rpm for 25 minutes. A 10 mL supernatant aliquot was dried in a pre-weighed aluminium dish at 105°C to constant weight, and the WSI was calculated using the formula: WSI (%) = [(W2 - W1) / W] × 100, where W2 is the weight of the dish with residue, W1 is the weight of the empty dish, and W is the dry sample weight.

2.4 DETERMINATION OF NUTRITIONAL PROPERTIES OF BAEL PULP SAMPLES

The proximate composition of dried pulp was analysed using standard methods. Crude fat was quantified via Soxhlet extraction apparatus (SOCS PLUS SCS 6) as per Rangana (2007), with a 2 g sample extracted in 125 mL n-hexane for 5 hours. Following extraction, the solvent was evaporated, and the residue dried at 100°C for 1 hour, with crude fat content calculated by the formula: Crude fat (%) = (Weight of hexane ‑ soluble material / Weight of sample) × 100.

Ash content was determined by incinerating a 10 g sample in a muffle furnace at 550°C until light grey ash formed (4-6 hours), and calculated as: Ash (%) = [(w2 - w1) / w3] × 100, where w1, w2, and w3 represent the weights of the empty crucible, crucible with ash, and sample, respectively.

Crude fiber was analysed using the Fibra Plus instrument by sequentially treating a 2 g sample with 1.25% H_2SO_4 and 1.25% NaOH, followed by incineration, with the formula: Crude fiber (%) = [(w2 - w3) / w1] × 100, where w1 is the sample weight, w2 the weight of crucible and sample after drying, and w3 the crucible with ash.

Crude protein was assessed using the Micro-Kjeldahl method, (AOAC, 2012) by using Electronic Socs plus automatic six place solvent extraction system (KEL PLUS – SUPRA LX) involving acid digestion, distillation, and titration, with nitrogen content (N %) calculated and converted to protein as Protein (%) = N (%) × 6.25.

Total carbohydrate content was calculated by difference as Total carbohydrates (%) = 100 - [Σ (moisture + crude protein + ash + crude fiber + crude fat)], following Rangana, (2007).

2.5 STATISTICAL ANALYSIS

The statistical analysis of the experimental data was done using SAS software v.2023.9.1. The one-way ANOVA was done by Duncan's Multiple Range Test (DMRT) method. The F-test was used to assess the overall variance (Rajeev et al., 2022).

3.1 RESULTS AND DISCUSSION

Initial Pulp

Dried Pulp at 55^{0}C

Dried Pulp at 65^{0}C

Dried Pulp at 75^{0}C

3.1 PHYSICAL PROPERTIES

3.1.1 TRUE DENSITY

Table 1 shows that true density of pulp samples increased significantly with temperature treatments, from 1.05 g/cc (S1) to 1.61 g/cc (S4). All treatments differed significantly, as indicated by analysed results The general mean density was 1.31 g/cc. The coefficient of variation (C.V.) was low at 1.8, suggesting consistent measurements. Standard error of the mean (S.E.M.) was 0.01. Critical difference values were 0.04 and 0.06 at 5% and 1% significance levels, respectively. True density increased with temperature, likely due to moisture loss and structural changes. Higher temperatures compacted the solid matter as water was expelled. Rodríguez-Ramírez et al. (2012) found similar results for fruit and vegetable samples.

3.1.2 BULK DENSITY

Bulk density of pulp samples varied significantly across temperature treatments (Table 1). The highest bulk density of 0.89 g/cc was observed in sample S1, followed by a notable decrease in sample S2 as 0.57 g/cc. Sample S3 showed a slight increase to 0.62 g/cc, while sample S4 exhibited the lowest bulk density at 0.48 g/cc. All treatments differed significantly from each other. The general mean bulk density was 0.64 g/cc. The coefficient of variation (C.V.) was exceptionally low at 1.06, indicating high precision in measurements. The standard error of the mean (S.E.M.) was reported as 0. Critical difference (C.D.) values were 0.01 and 0.02 at 5% and 1% significance levels, respectively. The distinct effects of each temperature on density, confirmed by significant differences between treatments, suggest important implications for texture, rehydration, and packaging. Alemu, (2023) found similar effects on bulk density during drying. The observed non-linear bulk density changes indicate structural reorganization and increased porosity, supported by the high reproducibility (low C.V., S.E.M., and C.D. values). Wang and Brennan (1995) reported similar trends.

Table 1. Physical properties of different pulp samples

Pulp samples	True Density (g/cc)	Bulk Density (g/cc)	L*	a*	b*
S1	1.05	0.89	52.1	15.77	56.3
S2	1.22	0.57	44.97	19.77	43.77
S3	1.38	0.62	53.27	12.47	47.97
S4	1.61	0.48	40.73	25.73	41.33
Gen. Mean	1.31	0.64	47.77	18.43	47.34
C.V.	1.8%	1.06%	2.86%	2.42%	2.45%
S.E.M.	0.01	0	0.79	0.26	0.67
C.D. 5%	0.04	0.01	2.58	0.84	2.18
C.D. 1%	0.06	0.02	3.75	1.22	3.18

3.1.3 COLOUR ANALYSIS

Table 1 shows that the samples S1 and S3 had highest L* (lightness) with values of 52.1 and 53.27, which are not significantly different from each other. The sample S2 was significantly darker (L* 44.97), than the sample S4 with L* of 40.73 displaying lowest lightness. The general mean for L* was 47.77, with a C.V. of 2.86 and S.E.M. of 0.79. The a* (redness) of sample S4 showed the highest redness 25.73, followed by 19.77 (sample S2), 15.77 (sample S1), and 12.47 (sample S3). All treatments differed significantly. The general mean for a* was 18.43, with a C.V. of 2.42 and S.E.M. of 0.26. The

b* (yellowness) of sample S1 exhibited the highest yellowness of 56.3, followed by 47.97 (sample S3), 43.77 (sample S2), and 41.33 (sample S4). All treatments differed significantly. The general mean for b* was 47.34, with a C.V. of 2.45 and S.E.M. of 0.67. Colour analysis reveals that drying temperatures significantly affect different Bael pulp samples visual properties. Decreasing L* values from pulp sample S1 to samples S2 to S4 suggest darkening, likely due to Maillard reactions or caramelization at higher temperatures similarly observed by Sonawane et al., (2020). However, sample S3 preserved lightness closer to the original pulp, indicating an optimal condition for colour retention.

3.2 CHEMICAL PROPERTIES

All determined chemical properties for different pulp samples are tabulated under Table 2.

3.2.1 WATER ACTIVITY

Water activity (a_w) in pulp decreased significantly with increasing drying air temperature. Initial a_w was 0.88, reducing to 0.48, 0.39, and 0.38 at higher temperatures. The general mean was 0.53, with a C.V. of 1.68. S.E.M. was 0.01, and C.D. at both 5% and 1% levels was 0.02, indicating statistically significant differences between samples (Tsami et al., 1998). The inverse relationship between drying temperature and water activity was most pronounced at lower temperatures. Final a_w values (0.38-0.39) indicate improved microbial stability, falling below critical thresholds for most bacteria and yeasts, though some molds may still pose risks (Santhalakshmy et al., 2015). Comparable water activity values were reported by Quek et al. (2007) for watermelon sample.

3.2.2 TOTAL SOLUBLE SOLIDS (TSS)

Total Soluble Solids (TSS) content varied significantly across different drying air temperature. The TSS values increased with temperature, ranging from 33.90 for sample S1 to 55.63 for sample S4. The general mean TSS was 49.95. The coefficient of variation (C.V.) was relatively high at 3.46%, indicating considerable variability among samples. The standard error of the mean (S.E.M.) was 1.09. Critical difference (C.D.) values were 3.26 at 5% significance and 4.74 at 1% significance level. The increase in TSS with temperature suggests a concentration effect from moisture removal, with the largest jump between sample S1 (33.90) and sample S4 (55.63), indicating a critical temperature range for rapid TSS concentration. High variability (C.V. 3.46%) suggests initial moisture differences or uneven drying. The statistically significant C.D. values indicate that treatment differences are meaningful, and the TSS increase could affect taste, texture, and preservation. Contrary to TSS trends, heat-sensitive components likely caused a reduction in TSS at higher temperatures, as seen in similar studies on foam-mat dried tomato sample by Kadam et al., (2012) and Alphonso papaya sample by Kandasamy et al., (2014).

3.2.3 MOISTURE CONTENT (WET BASIS)

Moisture content (wet basis) significantly decreased with increasing temperature treatments. The initial moisture content of sample S1 was 64.51%, which reduced drastically to 27.6% of sample S2, 11.7% of sample S3, and 9.08% of sample S4. The general mean moisture content across all treatments was 28.22%. The coefficient of variation (C.V.) was 2.57, indicating relatively low variability among samples. The standard error of the mean (S.E.M.) was 0.42. Critical difference (C.D.) values were 1.37 at 5%

significance level and 1.99 at 1% significance level. Moisture content decreased efficiently with higher temperatures, with the largest reduction between sample S1 and S2, indicating that early drying stages are critical for moisture removal. At higher temperatures, the rate of moisture loss slowed, with smaller differences between sample S3 and S4. Low variability (C.V. 2.57) suggests consistency in the drying process, and the final moisture content (9.08% at sample S4) likely enhances product stability by reducing water availability for microbial growth. This trend correlates with the increases in TSS and reductions in water activity. Similar findings were observed in drying tomato pulp by Goula et al., (2004) and pineapple pulp by Abadio et al., (2004).

3.2.4 PH

The pH of Bael pulp samples varied significantly across treatments (Fig. 1). The pulp sample S1 had the lowest pH at 4.1, indicating high acidity. Drying treatments increased pH, with sample S2 showing the highest value (5.59), while sample S3 and S4 both resulted in a pH of 5.21. The general mean pH was 5.03, with a low coefficient of variation (2.38) indicating consistent measurements. The standard error of the mean was 0.07, with critical difference values of 0.23 and 0.33 at 5% and 1% significance levels, respectively. The pH increase from pulp to sample suggests reduced acidity due to non-acidic compound concentration or organic acid volatilization at higher temperatures (Angle et al., 2022). The stabilization of pH at 5.21 for sample S3 and S4 could be a potential equilibrium point, with implications for flavour, microbial stability, and chemical reactions (Ozoh et al., 2024).

3.2.5 TITRABLE ACIDITY

The data shows that titrable acidity varies between different pulp samples, with dried pulp samples generally exhibiting higher acidity than fresh pulp sample. Sample S1 had the lowest acidity of 0.45%, while sample S3 had the highest acidity of 0.54%. The low coefficient of variation (2.3%) indicates consistent results across the treatments. The statistically significant differences in acidity, particularly between samples S1 and S3, imply that Bael sample concentrates organic acids more effectively than pulp, impacting flavour and preservation. Bandaru and Bakshi (2021) observed similar results for guava and apple.

3.2.6 WATER SOLUBILITY INDEX (WSI)

Fig. 1 shows that the Water Solubility Index (WSI) of sample S1 had the highest WSI at 0.92, while sample S4 had the lowest WSI at 0.74. The general mean WSI is 0.81, with a low coefficient of variation (2.02%), indicating consistent measurements. The differences are statistically significant, as shown by the critical differences (C.D. 5% = 0.03; C.D. 1% = 0.04). The significantly higher WSI in Bael pulp compared to sample may be due to processing methods affecting solubility, a finding also reported by Quek et al. (2007) for watermelon sample.

Table 2. Chemical properties of different pulp samples

Pulp samples	pH	Titrable Acidity (%)	Water Solubility Index	Ascorbic Acid (mg/100g)	Moisture Content (wb, %)	Water Activity	TSS (%)
S1	4.10	0.45	0.92	19.28	64.51	0.88	33.90
S2	5.59	0.49	0.81	14.13	27.6	0.48	54.96
S3	5.21	0.54	0.77	11.38	11.7	0.39	55.32
S4	5.21	0.50	0.74	7.12	9.08	0.38	55.63
Gen. Mean	5.03	0.50	0.81	12.98	28.22	0.53	49.95
C.V.	2.38%	2.30%	2.02%	39.27%	2.57%	1.68%	3.46%
S.E.M.	0.07	0.01	0.01	2.55	0.42	0.01	1.09
C.D. 5%	0.23	0.02	0.03	11.47	1.37	0.02	3.26
C.D. 1%	0.33	0.03	0.04	21.05	1.99	0.02	4.74

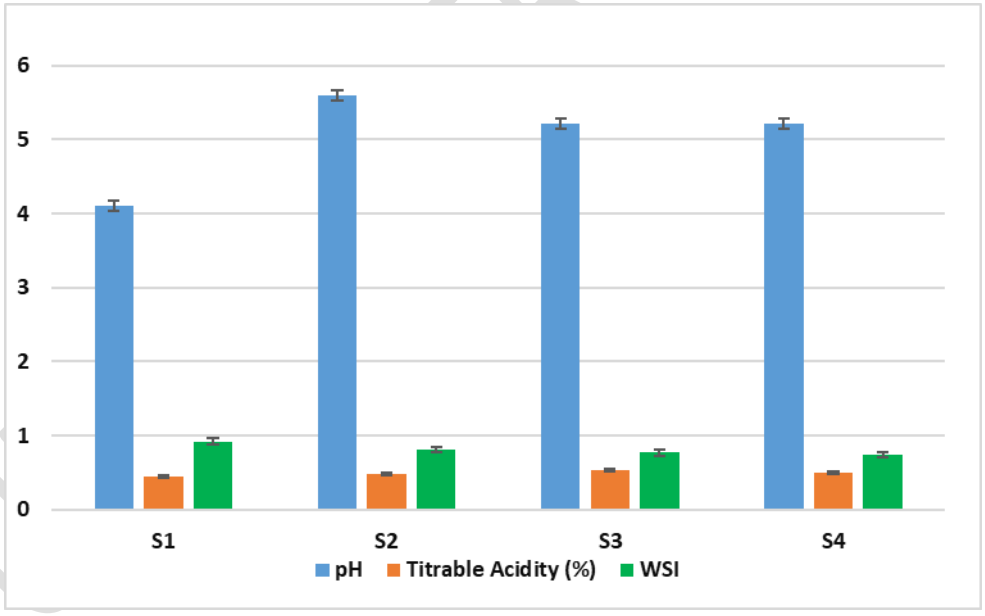

Fig. 1. Effect of different drying temperatures on chemical properties of Bael pulp samples

3.2.7 ASCORBIC ACID

The data of Table 2 shows a gradual decrease in ascorbic content as temperature rises. Sample S1 has ascorbic acid content of 19.28 mg/100gm and for sample S4 it came down to 7.12 mg/100gm. The C.D value at 5% was reported 11.47 and C.D value at 1% was reported 21.05. The inverse relationship

between drying temperature and ascorbic acid content reflects the heat-sensitive nature of this vitamin (Vikram et al., 2005). A 63.07% reduction from pulp to sample dried at 75°C highlights the impact of high-temperature processing on nutrient retention, consistent with results from Mercali et al. 2012 for acerola pulp.

3.3 NUTRITIONAL PROPERTIES

All determined nutritional properties for different pulp samples are tabulated under Table 3 and also displayed in Fig. 2

3.3.1 PROTEIN CONTENT

The initial protein content in the pulp sample S1 was approximately 7%. Upon drying at 55°C, a slight reduction in protein content was observed. When the drying temperature was increased to 65°C, the protein content showed a minor increase. However, a significant decrease in protein content occurred when the drying temperature was further elevated to 75°C. Drying enhances the storage stability of protein samples but may cause insoluble aggregates and protein denaturation (Feyzi et al., 2018). Most proteins coagulate between 71°C and 85°C, and increased temperatures lead to protein hardening and shrinkage.

3.3.2 FAT CONTENT

The fat percentage in the different samples of pulp varied significantly. Sample S1, had the lowest fat percentage at 0.12%. For sample S2, dried at 55°C, increased the fat percentage to 0.18%. For sample S3, dried at 65°C, showed a more substantial rise to 0.35%. The highest fat content, 0.75%, was observed in sample S4, where pulp was subjected to 75°C. The general mean was 1.5%, with a coefficient of variation (C.V.) of 1.75%. The standard error of mean (S.E.M.) was 2.5, with a critical difference (C.D.) of 3% at 5% significance and 3.56% at 1% significance. Page et al. (2019) found similar effects, with higher temperatures causing rapid moisture evaporation, concentrating fats and promoting fat globule coalescence. Wiking et al. (2022) found comparable results in milk sample.

3.3.3 CARBOHYDRATE CONTENT

The carbohydrate content varied significantly across pulp samples. Sample S2 (74.47 g/100g), sample S3, (64.23 g/100g), and sample S4, (54.66 g/100g) showed significantly higher carbohydrate levels compared to sample S1, (33.83 g/100g). The general mean carbohydrate content was 56.8 g/100g. The coefficient of variation (C.V.) was 30.49%, indicating a moderate level of variability. The standard error of mean (S.E.M.) was 8.66, and the critical difference (C.D.) was 27.55 at the 5% significance level and 50.57 at the 1% significance level. Carbohydrate content increased as moisture loss concentrated dry matter, though higher temperatures caused degradation of glycosidic bonds, leading to the loss of low-molecular-weight carbohydrates (Parwani & Singh, 2019). This temperature-dependent degradation affects the carbohydrate profile, as observed in starch granules undergoing structural changes during drying (Oyinloye & Yoon, 2020). These changes influence chemical reactivity and pasting behaviour.

3.3.4 FIBER CONTENT

The highest fiber content was observed in the pulp sample S1, (19.28), which decreased progressively with increasing drying air temperatures. Pulp dried at 55°C (sample S2) showed 14.13, followed by

65°C (sample S3) with 11.38, and the lowest at 75°C (sample S4) with 7.12. The general mean was 12.98, with a coefficient of variation of 39.27%. The standard error of the mean was 2.55, while the critical differences at 5% and 1% levels were 11.47 and 21.05, respectively. The drying process increased dietary fiber concentration in Bael sample, making it a valuable option for fiber-enriched products, similar to findings by VARO et al. (1984) for potato and tomato.

3.3.5 ASH CONTENT

Ash content varied significantly across different pulp samples. Sample S1 had the lowest ash content of 1.71%. Drying temperature increased ash content substantially, with sample S2 showing 4.1%, and sample S3 and sample S4 exhibiting the highest levels of 4.44% and 4.50% respectively, without significant difference between them. The general mean was 3.69%, with a low coefficient of variation (2.34%) indicating consistent measurements. The standard error of the mean was 0.05, with critical difference values of 0.16 and 0.24 at 5% and 1% significance levels, respectively. The increase in ash content from pulp to sample reflects mineral concentration due to moisture loss. The plateau at sample S3 and sample S4 suggests maximum mineral concentration.

Table 3. Nutritional properties of different pulp samples

Pulp samples	Protein (g/100g)	Fat (%)	Ash (%)	Carbohydrate (g/100g)	Fiber (g/100g)
S1	7.35	0.12	1.71	33.83	2.88
S2	6.45	0.18	4.10	74.47	5.45
S3	8.92	0.35	4.44	64.23	6.15
S4	2.95	0.75	4.50	54.66	6.54
Gen. Mean	6.42	1.50	3.69	56.80	5.25
C.V.	3.23%	1.75%	2.34%	30.49%	2.74%
S.E.M.	0.13	2.50	0.05	8.66	0.08
C.D. 5%	0.42	3.00	0.16	27.55	0.27
C.D. 1%	0.61	3.56	0.24	50.57	0.39

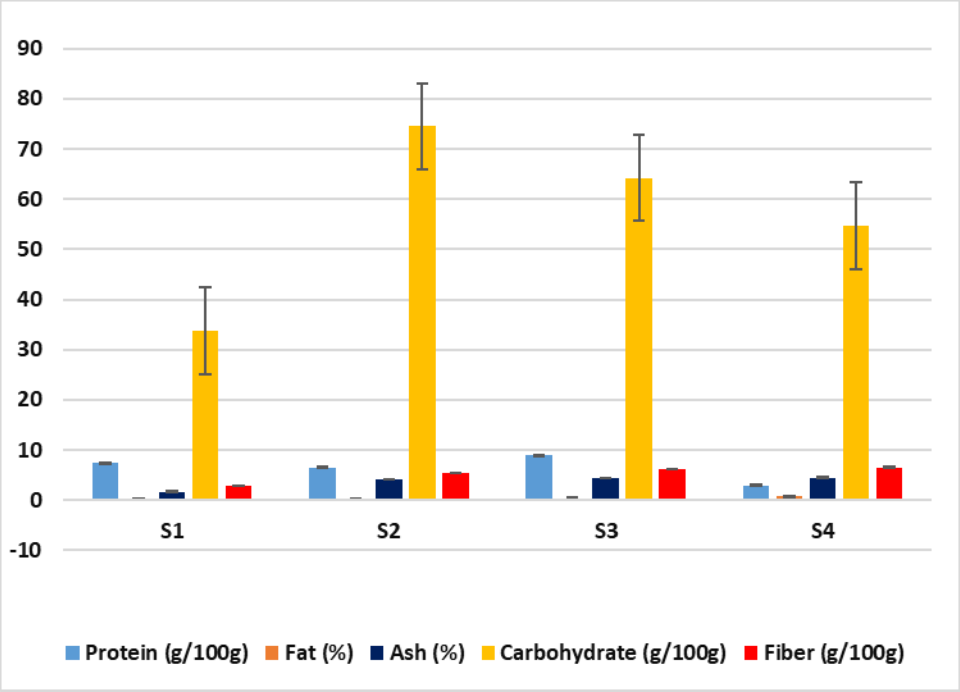

Fig. 2. Effect of different drying temperatures on the chemical properties of Bael pulp samples

4. CONCLUSION

The study on Bael fruit processing shows significant changes in physical, chemical, and nutritional properties with varying drying temperatures. Higher temperatures generally reduced water activity, moisture content, and ascorbic acid, while increasing TSS, true density, and ash content. Colour and bulk density followed non-linear trends. Protein and carbohydrate content initially rose but declined at higher temperatures due to thermal degradation. Fat and fiber content exhibited variable patterns. These findings underscore the complex relationship between drying conditions and product quality, emphasizing the importance of optimizing parameters to balance preservation, nutrition, and sensory attributes in dried Bael products.

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REFERENCES

Abadio, F. D. B., Domingues, A. M., Borges, S. V., & Oliveira, V. M. (2004). Physical properties of sampleed pineapple (Ananas comosus) juice - Effect of malt dextrin concentration and atomization speed. *Journal of Food Engineering*, *64*(3), 285–287. https://doi.org/10.1016/j.jfoodeng.2003.10.010

Anadani, S. V, Akbari, S. H., Nema, A., & Ravani, A. (2023). *Development of value added product form bael fruit (Aegle marmelos) sample*. *12*(4), 101–104. https://www.thepharmajournal.com/archives/2023/vol12issue4/PartB/12-4-363-148.pdf

Angle, K. J., Nowak, C. M., & Grassian, V. H. (2022). Organic acid evaporation kinetics from aqueous aerosols: implications for aerosol buffering capacity in the atmosphere. *Environmental Science: Atmospheres*, *3*(2), 316–327. https://doi.org/10.1039/d2ea00092j

Baliga, M. S., Bhat, H. P., Joseph, N., & Fazal, F. (2011). Phytochemistry and medicinal uses of the bael fruit (Aegle marmelos Correa): A concise review. *Food Research International*, *44*(7), 1768–1775. https://doi.org/10.1016/j.foodres.2011.02.008

Bandaru, H., & Bakshi, M. (2021). Effect of different drying conditions on the quality of apple and guava fruit leather. *The Pharma Innovation Journal*, *10*(8), 233–237. http://www.thepharmajournal.com

Bhattacherjee, A. K., Pandey, D., & Dikshit, A. (2019). Nutraceutical profiling of some indian bael (aegle marmelos correa) cultivars. *Fruits*, *74*(4), 187–193. https://doi.org/10.17660/th2019/74.4.5

Feyzi, S., Milani, E., & Golimovahhed, Q. A. (2018). Grass Pea (Lathyrus sativus L.) Protein Isolate: The Effect of Extraction Optimization and Drying Methods on the Structure and Functional Properties. *Food Hydrocolloids*, *74*, 187–196. https://doi.org/10.1016/j.foodhyd.2017.07.031

Goula, A. M., Adamopoulos, K. G., & Kazakis, N. A. (2004). Influence of spray drying conditions on tomato sample properties. *Drying Technology*, *22*(5), 1129–1151. https://doi.org/10.1081/DRT-120038584

Hossain, M. A., Mitra, S., Belal, M., & Zzaman, W. (2021). *Properties of Foam Mat Dried Tomato Sample*. *5*(February), 291–297.

Kadam, D. M., Wilson, R. A., Kaur, S., & Manisha. (2012). Influence of foam mat drying on quality of tomato sample. *International Journal of Food Properties*, *15*(1), 211–220. https://doi.org/10.1080/10942911003763701

Kandasamy, P., Varadharaju, N., Kalemullah, S., & Maladhi, D. (2014). Optimization of process parameters for foam-mat drying of papaya pulp. Journal of food science and technology, 51, 2526-2534. (n.d.). *tss pp.pdf*.

Kaur, R., Gul, K., & Singh, A. K. (2016). Nutritional impact of ohmic heating on fruits and vegetables—A review. *Cogent Food and Agriculture*, *2*(1). https://doi.org/10.1080/23311932.2016.1159000

Mercali, G. D., Jaeschke, D. P., Tessaro, I. C., & Marczak, L. D. F. (2012). Study of vitamin C degradation in acerola pulp during ohmic and conventional heat treatment. *Lwt*, *47*(1), 91–95. https://doi.org/10.1016/j.lwt.2011.12.030

Oyinloye, T. M., & Yoon, W. B. (2020). Effect of freeze-drying on quality and grinding process of food produce: A review. In *Processes* (Vol. 8, Issue 3). https://doi.org/10.3390/PR8030354

Ozoh, C., Imoisi, C., & Iyasele, J. U. (2024). Effect of pH and Duration of Fermentation on the Sensory, Physicochemical and Proximate Characteristics of Garri. *Trends in Applied Sciences Research*, *19*(1), 156–169. https://doi.org/10.3923/tasr.2024.156.169

Page, N., Biocatal, L. De, Abrogoua, U. N., Abidjan, B. P., & Ivoire, C. (2019). *World Journal of Advance Effect of Temperature-Time Pair on the Nutritional Value and Antioxidant Activity of Tetrapleura Tetraptera Heated Pulp Sample*. *3*(5).

Parwani, L., & Singh, J. (2019). Effect of Temperature on Nutritional Values of Spirulina: Useful for Nutrient Sustainable Food Preparations to Combat Malnutrition. *Proceedings of the National Academy of Sciences India Section B - Biological Sciences*, *89*(4), 1259–1265. https://doi.org/10.1007/s40011-018-1033-6

Quek, S. Y., Chok, N. K., & Swedlund, P. (2007). The physicochemical properties of spray-dried watermelon samples. *Chemical Engineering and Processing: Process Intensification*, *46*(5), 386–392. https://doi.org/10.1016/j.cep.2006.06.020

Rahman, M. T., Halim, M. A., Mozumder, N. R., Ove, T. A., & Khatun, A. A. (2024). Phytochemicals and antioxidant properties of bael (Aegle marmelos L.) pulp powder and its products. *Journal of Agriculture and Food Research*, *15*, 100971.

Rodríguez-Ramírez, J., Méndez-Lagunas, L., López-Ortiz, A., & Torres, S. S. (2012). True Density and Apparent Density During the Drying Process for Vegetables and Fruits: A Review. *Journal of Food Science*, *77*(12), 145–154. https://doi.org/10.1111/j.1750-3841.2012.02990.x

Saha, A., & Jindal, N. (2018). Process optimization for the preparation of bael (Aegle marmelos correa) fruit sample by spray drying. *International Journal of Food Science and Nutrition*, *3*(4), 44–51. https://www.researchgate.net/profile/ApurbaSaha/publication/326478176_Process_optimization_for_the_preparation_of_bael_Aegle_marmelos_correa_fruit_sample_by_spray_drying/links/5b5033610f7e9b240fec2090/Process-optimization-for-the-preparation-of-bael-Aegl

Santhalakshmy, S., Don Bosco, S. J., Francis, S., & Sabeena, M. (2015). Effect of inlet temperature on physicochemical properties of spray-dried jamun fruit juice sample. *Sample Technology*, *274*, 37–43. https://doi.org/10.1016/j.powtec.2015.01.016

Sarkar, T., Salauddin, M., & Chakraborty, R. (2020). In-depth pharmacological and nutritional properties of bael (Aegle marmelos): A critical review. *Journal of Agriculture and Food Research*, *2*(October), 100081. https://doi.org/10.1016/j.jafr.2020.100081

Sonawane, A., Pathak, S., & Pradhan, R. C. (2020). Effect of processing temperature on dynamic rheological properties and color degradation kinetics of bael fruit pulp. *Journal of the Science of Food and Agriculture*, *100*(15), 5596–5602. https://doi.org/10.1002/jsfa.10612

Tinebra, I., Passafiume, R., Scuderi, D., Pirrone, A., Gaglio, R., Palazzolo, E., & Farina, V. (2022). Effects of Tray-Drying on the Physicochemical, Microbiological, Proximate, and Sensory Properties of White- and Red-Fleshed Loquat (Eriobotrya Japonica Lindl.) Fruit. *Agronomy*, *12*(2), 540. https://doi.org/10.3390/agronomy12020540

Thakur, R. R., Mangaraj, S., Kate, A. E., Sami, R., Al-Mushhin, A. A., Maklad, M. F., ... & Helal, M. (2022). Effect of harvesting stages and storage temperature on quality attributes and post-harvest shelf-life of mango (Mangifera indica). *Journal of Biobased Materials and Bioenergy*, *16*(5), 770-782.

VARO, P., VEIJALAINEN, K., & KOIVISTOINEN, P. (1984). Effect of heat treatment on the dietary fibre contents of potato and tomato. *International Journal of Food Science & Technology*, *19*(4), 485–492. https://doi.org/10.1111/j.1365-2621.1984.tb00372.x

Wang, N., & Brennan, J. G. (1995). Changes in structure, density and porosity of potato during dehydration. *Journal of Food Engineering*, *24*(1), 61–76. https://doi.org/10.1016/0260-8774(94)P1608-Z

Wiking, L., Gregersen, S. B., Hansen, S. F., & Hammershøj, M. (2022). Heat-induced changes in milk fat and milk fat globules and its derived effects on acid dairy gelation – A review. *International Dairy Journal*, *127*, 105213. https://doi.org/10.1016/j.idairyj.2021.105213